Chemistry

Subject guide

First Examinations 2016

ANATOLIA COLLEGE, IBDP

Revised July 2018

1. Nature of the subject

Chemistry is an experimental science which combines academic study with the acquisition of practical and investigational skills. Chemical principles underpin both the physical environment in which we live and all biological systems.

The study of chemistry has changed dramatically from its origins in the early days of alchemists, who had as their quest the transmutation of common metals into gold. Although today alchemists are not regarded as being true scientists, modern chemistry has the study of alchemy as its roots. Alchemists were among the first to develop strict experimentation processes and laboratory techniques. Robert Boyle, often credited with being the father of modern chemistry, began experimenting as an alchemist.

Despite the exciting and extraordinary development of ideas throughout the history of chemistry, certain things have remained unchanged. Observations remain essential at the very core of chemistry, and this sometimes requires decisions about what to look for. The scientific processes carried out by the most eminent scientists in the past are the same ones followed by working chemists today and, crucially, are also accessible to students in schools. The body of scientific knowledge has grown in size and complexity, and the tools and skills of theoretical and experimental chemistry have become so specialized, that it is difficult (if not impossible) to be highly proficient in both areas. While students should be aware of this, they should also know that the free and rapid interplay of theoretical ideas and experimental results in the public scientific literature maintains the crucial link between these fields.

The Diploma Programme chemistry course includes the essential principles of the subject but also, through selection of an option, allows teachers some flexibility to tailor the course to meet the needs of their students. The course is available at both standard level (SL) and higher level (HL), and therefore accommodates students who wish to study chemistry as their major subject in higher education and those who do not.

2. Aims and assessment objectives

Aims

Through the study of chemistry as well as the other group 4 subjects, students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterizes these subjects.

The aims enable students, through the overarching theme of the Nature of science, to:

1. appreciate scientific study and creativity within a global context through stimulating and challenging opportunities
2. acquire a body of knowledge, methods and techniques that characterize science and technology
3. apply and use a body of knowledge, methods and techniques that characterize science and technology
4. develop an ability to analyse, evaluate and synthesize scientific information
5. develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
6. develop experimental and investigative scientific skills including the use of current technologies
7. develop and apply 21st century communication skills in the study of science
8. become critically aware, as global citizens, of the ethical implications of using science and technology
9. develop an appreciation of the possibilities and limitations of science and technology
10. develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge.

Assessment objectives

1. Demonstrate knowledge and understanding of: a. facts, concepts, and terminology b. methodologies and techniques c. communicating scientific information.
2. Apply: a. facts, concepts, and terminology b. methodologies and techniques c. methods of communicating scientific information.
3. Formulate, analyse and evaluate: a. hypotheses, research questions and predictions b. methodologies and techniques c. primary and secondary data d. scientific explanations.
4. Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations.

Differences between SL and HL

Group 4 students at standard level (SL) and higher level (HL) undertake a common core syllabus, a common internal assessment (IA) scheme and have some overlapping elements in the option studied. While the skills and activities of group 4 science subjects are common to students at both SL and HL, students at HL are required to study some topics in greater depth, in the additional higher level (AHL) material and in the common options. On a weekly basis this is translated to 4 teaching hours for SL students compared to 6 teaching for HL students. HL students are also expected to perform more and more complex laboratory investigations (40h for SL and 60h for HL students).

3. Subject outline

Core

1. Stoichiometric relationships
2. Atomic structure
3. Periodicity
4. Chemical bonding and structure
5. Energetics/thermochemistry
6. Chemical kinetics
7. Equilibrium

8. Acids and bases

9. Redox processes

10. Organic chemistry

11. Measurement and data processing

Additional higher level (AHL)

12. Atomic structure

13. The periodic table—the transition metals

14. Chemical bonding and structure

15. Energetics/thermochemistry

16. Chemical kinetics

17. Equilibrium

18. Acids and bases

19. Redox processes

20. Organic chemistry

21. Measurement and analysis

Options

A. Materials, B. Biochemistry, C. Energy, D. Medicinal chemistry

Skills to be developed

Apart from their experience in the classroom students in all group 4 subjects are expected to also gain real laboratory experience through a series of practical investigations during both IB years. These practical activities will allow students to interact directly with natural phenomena and secondary data sources. Students are expected, after meaningful training, not only to be able to follow guidelines, replicate an experimental procedure and work safely n a laboratory environment, but also to design investigations, collect data, develop manipulative skills, analyse results, collaborate with peers and evaluate and communicate their findings. Experiments can be used to introduce a topic, investigate a phenomenon or to allow students to examine questions and curiosities. Once developed, these higher order thinking skills will enable students to be lifelong learners and scientifically literate. The approach of teaching IB Chemistry is clearly an experimental one.

The school's practical scheme of work will allow students to experience the full breadth and depth of the course including the option. This practical scheme of work will also prepare students to undertake the individual investigation that is required for the internal assessment. The detailed version of the syllabus lists specific lab skills, techniques and experiments that students must experience at some point during their study of their group 4 course. Other recommended lab skills, techniques and experiments are listed in the "Aims" section of the subject-specific syllabus pages. Aim 6 of the group 4 subjects directly relates to the development of experimental and investigative skills.

Teaching Techniques

A variety of teaching methods are employed in teaching the IB Chemistry course:

1. Lectures supported by power point presentations
2. Class discussion/Discussion groups
3. Experiment investigations (usually one per chapter)
4. In-class assignments
5. Individual projects
6. Student Poster Sessions
7. Computer simulations
8. Short videos/animations
9. Presentations by students (usually in the Options section)
10. Brainstorming in small groups or individually.
11. Peer Evaluation

Nature of Science

The connection with real life situations and their connection to science is ingregated in the new Chemistry guide through the implementation of the Nature of science (NOS) is an overarching theme in the biology, chemistry and physics courses. The "Nature of science" section of the guide provides a comprehensive

account of the nature of science in the 21st century and the intrechangable connections between science and technology.

Chemistry and ICT

The use of information communication technology (ICT) is encouraged throughout all aspects of the course and will be implemented in both the practical programme and day-to-day classroom activities.

Chemistry and future studies

Concerning future studies, apart from being a subject worthy of study in its own right, chemistry is a prerequisite for many other courses in higher education, such as medicine, biological science and environmental science, and serves as useful preparation for employment.

4. Prior learning

Past experience shows that students will be able to study a group 4 science subject at SL successfully with no background in, or previous knowledge of, science. Their approach to learning, characterized by the IB learner profile attributes, will be significant here.

However, for most students considering the study of a group 4 subject at HL, while there is no intention to restrict access to group 4 subjects, some previous exposure to formal science education would be necessary. Students who have undertaken the MYP science, design and mathematics courses will be well prepared for group 4 subjects.

5. Chemistry and the IB Learner Profile.

All aspects of IB learner profile are promoted and some indicative examples are listed here:

•Inquirer: through designing investigations.

• Thinker: through learning to evaluate hypotheses, research questions and methods both in the students' own work and in the work of others.

•Communicator: through collaborating with peers in group-4 project and using the appropriate scientific language both in written and oral work.

• Principled: through acquiring scientific integrity in handling their own and other people's data and ideas and also referencing other people work.

• Reflective: through evaluating their practical work.

• Caring: through understanding the implications of human activities and scientific achievements on environment and society.

• Risk-taker: in designing investigations.

• Reflective: through group-4 project and self evaluations.

6. Chemistry and Core Components

Chemistry and TOK

The theory of knowledge (TOK) course engages students in reflection on the nature of knowledge and on how we know what we claim to know. Students explore these means of producing knowledge within the context of various areas of knowledge: the natural sciences, the social sciences, the arts, ethics, history,

mathematics, religious knowledge systems and indigenous knowledge systems. TOK lessons can support students in their study of science, just as the study of science can support students in their TOK course. TOK provides a space for students to engage in stimulating wider discussions about questions such as what it means for a discipline to be a science, or whether there should be ethical constraints on the pursuit of scientific knowledge and also provides an opportunity for students to reflect on the methodologies of science, and how these compare to the methodologies of other areas of knowledge. Also students are encouraged to compare and contrast scientific methods with the methods found in, for example, the arts or in history.

Chemistry and CAS

The environmental issues related to CAS offer a very good ground for experiential learning which is the main way of learning through CAS.

Chemistry and EE

The extended essay offers an opportunity for IB students to investigate a topic of special interest, in the form of a 4,000-word piece of independent research. When the area of research undertaken is Chemistry students are given the opportunity to investigate a particular aspect of the materials of our environment. Such extended essays will be characterized by a particular chemical emphasis within a more general set of research criteria. The outcome of the research should be a coherent and structured piece of writing that effectively addresses a particular issue or research question and arrives at a particular, and preferably personal, conclusion. (Adapted from the EE Guide-First Exams 2009).

7. Course structure and planning

Planning of the course

- An outline of the course syllabus is given in the Appendix 1 of this guide. Chapters 1-7 are taught during the first IB year, while Chapters 8-10 as well as the Option during the second year of the IBDP. Chapter 11 is introduced in the

first semester of the IB1 year , but some of the techniques discussed there are also discussed together with the respective laboratory investigations.

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Chemistry and international mindness- promoting awareness of individual, local, national and world issues

The power of scientific knowledge to transform societies is unparalleled. It has the potential to produce great universal benefits, or to reinforce inequalities and cause harm to people and the environment. In line with the IB mission statement, group 4 students need to be aware of the moral responsibility of scientists to ensure that scientific knowledge and data are available to all countries on an equitable basis and that they have the scientific capacity to use this for developing sustainable societies. Students' attention should be drawn to sections of the syllabus with links to international-mindedness. Examples of issues relating to international-mindedness are given within sub-topics in the syllabus content. Teachers could also use resources found on the Global Engage website (http://globalengage.ibo.org). (*Adapted from the IBO Chemistry Guide-First Exams 2016).*

Expected workload

Students are expected work on a minimum of 4-6 hours per week, revising the theory discussed in class, preparing homework and class assignments and also reports on the practical .

8. Assessment

In school regular assessment practices

These are both formative and summative. During the terms the theory is assessed by quizzes, tests and homework as well as contribution to class discussions. The practical investigations are assessed through the assessment of the lab reports that the students submit every one or two months. In mid-term, mock and final exams the students' tests are consisting of past paper questions based on previous IBO exams.

Formal IBO assessment

The formal IBO assessment consists of the External Assessment (accounting for 80% of the final grade) and of the Internal Assessment (accounting for 20% of the final grade).

The Final IB Diploma Grade

The Final IBDP Grade is derived by adding the grade obtained in each of the 6 subjects that a student has selected. Furthermore, the combination of the grade achieved in the Extended Essay and of the grade achieved in the Theory of Knowledge, can lead to a minimum of 0 and a maximum of 3 extra points to be added in the Final IBDP grade.

Subject group grade descriptors

For the Sciences (Group 4 Subjects) there exist specific grade descriptors:

Grade 7

Displays comprehensive knowledge of factual information in the syllabus and a thorough command of concepts and principles. Selects and applies relevant information, concepts and principles in a wide variety of contexts. Analyses and evaluates quantitative and/or qualitative data thoroughly. Constructs detailed explanations of complex phenomena and makes appropriate predictions. Solves most quantitative and/or qualitative problems proficiently. Communicates logically and concisely using appropriate terminology and conventions. Shows insight or originality. Demonstrates personal skills, perseverance and responsibility in a wide variety of investigative activities in a very consistent manner. Works very well within a team and approaches investigations in an ethical manner, paying full attention to environmental impact. Displays competence in a wide range of investigative techniques, pays considerable attention to safety, and is fully capable of working independently.

Grade 6

Displays very broad knowledge of factual information in the syllabus and a thorough understanding of concepts and principles. Selects and applies relevant

information, concepts and principles in most contexts. Analyses and evaluates quantitative and/or qualitative data with a high level of competence. Constructs explanations of complex phenomena and makes appropriate predictions. Solves basic or familiar problems and most new or difficult quantitative and/or qualitative problems. Communicates effectively using appropriate terminology and conventions. Shows occasional insight or originality. Demonstrates personal skills, perseverance and responsibility in a wide variety of investigative activities in a very consistent manner. Works well within a team and approaches investigations in an ethical manner, paying due attention to environmental impact. Displays competence in a wide range of investigative techniques, pays due attention to safety and is generally capable of working independently.

Grade 5

Displays broad knowledge of factual information in the syllabus. Shows sound understanding of most concepts and principles and applies them in some contexts. Analyses and evaluates quantitative and/or qualitative data competently. Constructs explanations of simple phenomena. Solves most basic or familiar problems and some new or difficult quantitative and/or qualitative problems. Communicates clearly with little or no irrelevant material. Demonstrates personal skills, perseverance and responsibility in a variety of investigative activities in a fairly consistent manner. Generally works well within a team and approaches investigations in an ethical manner, paying attention to environmental impact. Displays competence in a range of investigative techniques, pays attention to safety and is sometimes capable of working independently.

Grade 4

Displays reasonable knowledge of factual information in the syllabus, though possibly with some gaps. Shows adequate comprehension of most basic concepts and principles but with limited ability to apply them. Demonstrates some analysis or evaluation of quantitative or qualitative data. Solves some basic or routine problems but shows limited ability to deal with new or difficult situations. Communicates adequately although responses may lack clarity and

include some repetitive or irrelevant material. Demonstrates personal skills, perseverance and responsibility in a variety of investigative activities, although displays some inconsistency. Works within a team and generally approaches investigations in an ethical manner, with some attention to environmental impact. Displays competence in a range of investigative techniques, pays some attention to safety although requires some close supervision.

Grade 3

Displays limited knowledge of factual information in the syllabus. Shows a partial comprehension of basic concepts and principles and a weak ability to apply them. Shows some ability to manipulate data and solve basic or routine problems. Communicates with a possible lack of clarity and uses some repetitive or irrelevant material. Demonstrates personal skills, perseverance and responsibility in some investigative activities in an inconsistent manner. Works within a team and sometimes approaches investigations in an ethical manner, with some attention to environmental impact. Displays competence in some investigative techniques, occasionally pays attention to safety, and requires close supervision.

Grade 2

Displays little recall of factual information in the syllabus. Shows weak comprehension of basic concepts and principles with little evidence of application. Exhibits minimal ability to manipulate data and little or no ability to solve problems. Offers responses which are often incomplete or irrelevant. Rarely demonstrates personal skills, perseverance or responsibility in investigative activities. Works within a team occasionally but makes little or no contribution. Occasionally approaches investigations in an ethical manner, but shows very little awareness of the environmental impact. Displays competence in a very limited range of investigative techniques, showing little awareness of safety factors and needing continual and close supervision.

Grade 1

Recalls fragments of factual information in the syllabus and shows very little understanding of any concepts or principles. Rarely demonstrates personal skills, perseverance or responsibility in investigative activities. Does not work within a team. Rarely approaches investigations in an ethical manner, or shows an awareness of the environmental impact. Displays very little competence in investigative techniques generally pays no attention to safety and requires constant supervision.

9. Academic Honesty

Academic honesty in the Diploma Programme is a set of values and behaviours informed by the attributes of the learner profile. In teaching, learning and assessment, academic honesty serves to promote personal integrity, engender respect for the integrity of others and their work, and ensure that all students have an equal opportunity to demonstrate the knowledge and skills they acquire during their studies.

All Chemistry coursework—lab reports, internal assessment, extended essay, group 4 project—is to be authentic, based on the student's individual and original ideas with the ideas and work of others fully acknowledged. Assessment tasks that require teachers to provide guidance to students or that require students to work collaboratively must be completed in full compliance with the detailed guidelines provided by the IB for the relevant subjects.

Apart from the publications on academic honesty coming from the IBO: IB publications Academic honesty (2011), The Diploma Programme: From principles into practice (2009) and General regulations: Diploma Programme (2011) the school has developed its own Academic Honesty policy and students should access all the above sources.

All types of students' work in the subject are submitted as turnitin in assignments.

Appendix 1: Syllabus details

Core	95 hours
Topic 1: Stoichiometric relationships	**13.5**
1.1 Introduction to the particulate nature of matter and chemical change	
1.2 The mole concept	
1.3 Reacting masses and volumes	
Topic 2: Atomic structure	**6**
2.1 The nuclear atom	
2.2 Electron configuration	
Topic 3: Periodicity	**6**
3.1 Periodic table	
3.2 Periodic trends	
Topic 4: Chemical bonding and structure	**13.5**
4.1 Ionic bonding and structure	
4.2 Covalent bonding	
4.3 Covalent structures	
4.4 Intermolecular forces	
4.5 Metallic bonding	
Topic 5: Energetics/thermochemistry	**9**
5.1 Measuring energy changes	
5.2 Hess's Law	
5.3 Bond enthalpies	
Topic 6: Chemical kinetics	**7**
6.1 Collision theory and rates of reaction	
Topic 7: Equilibrium	**4.5**
7.1 Equilibrium	

	Recommended teaching hours
Topic 8: Acids and bases	**6.5**
8.1 Theories of acids and bases	
8.2 Properties of acids and bases	
8.3 The pH scale	
8.4 Strong and weak acids and bases	
8.5 Acid deposition	
Topic 9: Redox processes	**8**
9.1 Oxidation and reduction	
9.2 Electrochemical cells	
Topic 10: Organic chemistry	**11**
10.1 Fundamentals of organic chemistry	
10.2 Functional group chemistry	
Topic 11: Measurement and data processing	**10**
11.1 Uncertainties and errors in measurement and results	
11.2 Graphical techniques	
11.3 Spectroscopic identification of organic compounds	
Additional higher level (AHL)	**60 hours**
Topic 12: Atomic structure	**2**
12.1 Electrons in atoms	
Topic 13: The periodic table—the transition metals	**4**
13.1 First-row d-block elements	
13.2 Coloured complexes	
Topic 14: Chemical bonding and structure	**7**
14.1 Covalent bonding and electron domain and molecular geometries	
14.2 Hybridization	
Topic 15: Energetics/thermochemistry	**7**
15.1 Energy cycles	
15.2 Entropy and spontaneity	

	Recommended teaching hours
Topic 16: Chemical kinetics	**6**
16.1 Rate expression and reaction mechanism	
16.2 Activation energy	
Topic 17: Equilibrium	**4**
17.1 The equilibrium law	
Topic 18: Acids and bases	**10**
18.1 Lewis acids and bases	
18.2 Calculations involving acids and bases	
18.3 pH curves	
Topic 19: Redox processes	**6**
19.1 Electrochemical cells	
Topic 20: Organic chemistry	**12**
20.1 Types of organic reactions	
20.2 Synthetic routes	
20.3 Stereoisomerism	
Topic 21: Measurement and analysis	**2**
21.1 Spectroscopic identification of organic compounds	

Options — 15 hours (SL)/25 hours (HL)

A: Materials

Core topics

A.1 Materials science introduction

A.2 Metals and inductively coupled plasma (ICP) spectroscopy

A.3 Catalysts

A.4 Liquid crystals

A.5 Polymers

A.6 Nanotechnology

A.7 Environmental impact—plastics

Additional higher level topics

A.8 Superconducting metals and X-ray crystallography (HL only)

A.9 Condensation polymers (HL only)

A.10 Environmental impact—heavy metals (HL only)

B: Biochemistry

Core topics

B.1 Introduction to biochemistry

B.2 Proteins and enzymes

B.3 Lipids

B.4 Carbohydrates

B.5 Vitamins

B.6 Biochemistry and the environment

Additional higher level topics

B.7 Proteins and enzymes (HL only)

B.8 Nucleic acids (HL only)

B.9 Biological pigments (HL only)

B.10 Stereochemistry in biomolecules (HL only)

C: Energy

Core topics

C.1 Energy sources

C.2 Fossil fuels

C.3 Nuclear fusion and fission

C.4 Solar energy

C.5 Environmental impact—global warming

Additional higher level topics

C.6 Electrochemistry, rechargeable batteries and fuel cells (HL only)

C.7 Nuclear fusion and nuclear fission (HL only)

C.8 Photovoltaic and dye-sensitized solar cells (HL only)

D: Medicinal chemistry

Core topics

D.1 Pharmaceutical products and drug action

D.2 Aspirin and penicillin

D.3 Opiates

D.4 pH regulation of the stomach

D.5 Anti-viral medications

D.6 Environmental impact of some medications

Additional higher level topics

D.7 Taxol—a chiral auxiliary case study (HL only)

D.8 Nuclear medicine (HL only)

D.9 Drug detection and analysis (HL only)

Appendix 2: Assessment details

External assessment details—HL

First assessment 2016

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration (hours)
		1+2	3	
Paper 1	20	10	10	1
Paper 2	36	18	18	2¼
Paper 3	24	12	12	1¼
Internal assessment	20	Covers objectives 1, 2, 3 and 4		10

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External assessment details—SL

First assessment 2016

Component	Overall weighting (%)	Approximate weighting of objectives (%)		Duration (hours)
		1+2	3	
Paper 1	20	10	10	¾
Paper 2	40	20	20	1¼
Paper 3	20	10	10	1
Internal assessment	20	Covers objectives 1, 2, 3 and 4		10

Internal assessment component

Duration: 10 hours
Weighting: 20%

- Individual investigation
- This investigation covers assessment objectives 1, 2, 3 and 4.

Internal assessment criteria

The new assessment model uses five criteria to assess the final report of the individual investigation with the following raw marks and weightings assigned:

Personal engagement	Exploration	Analysis	Evaluation	Communication	Total
2 (8%)	6 (25%)	6 (25%)	6 (25%)	4 (17%)	24 (100%)

External assessment details—HL

Paper 1

Duration: 1 hour
Weighting: 20%
Marks: 40

- 40 multiple-choice questions on core and AHL, about 15 of which are common with SL.
- The questions on paper 1 test assessment objectives 1, 2 and 3.
- The use of calculators is not permitted.
- Students will be provided with a periodic table.
- No marks are deducted for incorrect answers.

Paper 2

Duration: 2¼ hours
Weighting: 36%
Marks: 95

- Short-answer and extended-response questions on the core and AHL material.
- The questions on paper 2 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.

Paper 3

Duration: 1¼ hours
Weighting: 24%
Marks: 45

- This paper will have questions on core, AHL and option material.
- Section A: one data-based question and several short-answer questions on experimental work.
- Section B: short-answer and extended-response questions from one option.
- The questions on paper 3 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.

External assessment details—SL

Paper 1

Duration: 3/4 hour
Weighting: 20%
Marks: 30

- 30 multiple-choice questions on core, about 15 of which are common with HL.
- The questions on paper 1 test assessment objectives 1, 2 and 3.
- The use of calculators is not permitted.
- Students will be provided with a periodic table.
- No marks are deducted for incorrect answers.

Paper 2

Duration: 1¼ hours
Weighting: 40%
Marks: 50

- Short-answer and extended-response questions on core material.
- The questions on paper 2 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.

Paper 3

Duration: 1 hour
Weighting: 20%
Marks: 35

- This paper will have questions on core and SL option material.
- Section A: one data-based question and several short-answer questions on experimental work.
- Section B: short-answer and extended-response questions from one option.
- The questions on paper 3 test assessment objectives 1, 2 and 3.
- The use of calculators is permitted. (See calculator section on the OCC.)
- A chemistry data booklet is to be provided by the school.

(Revised by:E.Antonakou, July 2018)